Agriculture and Forestry Technical Work Group
Policy Option Descriptions
For the May 16, 2006 CCAG Meeting

NOTES:

Document format: This revised format for policy descriptions and results is consistent with forms used at the most recent CCAG meeting, and will be used for (appendices to) the draft final report.

Yellow highlights: These indicate comments or changes to the policy option write-ups since the most recent TWG Call.

Data gaps: CCS is still working with TWG members to identify data sources and methods for analysis for some options. In some cases, initial draft estimates of GHG reduction benefits have been quantified; however, information on costs is lacking. In other cases, we are still working up both estimates of GHG reductions and costs. Note also that changes will be made to these initial estimates following review by the TWG to GHG reductions and costs by applying the appropriate discounting methods shown in the economics memo posted on the TWG website.

Policy overlaps: Note that there may be some double counting of savings among several of the measures analyzed here. For example, GHG reductions associated with biomass energy utilization from biomass supply quantified from options F3a and F3b will overlap with GHG reductions achieved by commercializing biomass gasification/combined cycle technology in option F4 (since the biomass energy from F3a and b will serve as input to F4).

Table 9.

Agriculture and Forestry Technical Work Group

Summary List of Draft Policy Options (15 Total)

#	Policy Name	GHG Savings ($MMtCO_2e$)	Cost Effectiveness ($\$/tCO_2e$)
	FORESTRY		
F-1	Forestland Protection from Developed Uses	2010: 0.3 2020: 0.3	TBD
F-2	Reforestation/Restoration of Forestland	2010: 0.02 2020: 0.2	TBD
F-3a	Forest Ecosystem Management – Residential Lands	2010: 0.5 2020: 0.5	-$56
F-3b	Forest Ecosystem Management – Other Lands	2010: 0.2 2020: 0.2	-$56
F-4	Improved Commercialization of Biomass Gasification and Combined Cycle	TBD	TBD
	AGRICULTURE		
A-1a	Manure Management – Manure Digesters	2010: 0.1 2020: 0.4	$6.83 (dairies only)
A-1b	Manure Management – Land Application	TBD	TBD
A-2	Biomass Feedstocks for Electricity or Steam/Direct Heat	2010: 0.04 2020: 0.1	-$63
A-3	Ethanol Production	2010: 0.49 2020: 0.64	TBD
A-4	Change Feedstocks (optimize for CH4 and/or N_2O reduction)	2010: 0.03 2020: 0.07	$165
A-5	*Reduce Non-Farm Fertilizer Use*	*N/A*	*N/A*
A-6	Grazing Management	TBD	TBD
A-7	Convert Land to Grassland or Forest	TBD	TBD
A-8	Agricultural Land Protection from Developed Uses	2010: 0.2 2020: 0.5	TBD
A-9	Programs to Support Local Farming/Buy Local	2010: 0.003 2020: 0.01	TBD

Table 10.

Description of Draft Agriculture and Forestry Policy Options

F-1 Forestland Protection from Developed Uses

Policy Description: Reduce the rate at which existing forestlands and forest cover are cleared and converted to developed uses or damaged by development that reduces productivity.

Policy Design:

- **Goal levels:** Given the considerable carbon storage potential of forest and woodlands in Arizona, and the trend of loss of these vegetation types in the past two decades, we propose that policy initiatives decrease the conversion of forest and woodlands to urban and other developed uses to 50 percent or less of the rates of loss to these uses during the 1987-1997 period by 2010 and continuing through 2020. If a 50% reduction in conversion rates of forest to urban or other developed uses were achieved, this would translate to a decreased conversion rate of 380 acres/year to 190 acres/year (based on the FIA, NRI data estimates). If the rangeland type were assumed to include about 50% pinyon-juniper type, a 50% reduction in conversion rate would translate to decreased conversion rates of woodlands to urban or developed uses of 8,530 acres/year to a reduced rate of 4,260 acres/year.
- **Timing:** see discussion above
- **Parties:**
- **Other:**

Implementation method(s): To be determined.

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO_2: Carbon savings occur when live carbon stocks (trees, shrubs, and some soil organic carbon) are protected from clearing and the associated decay or combustion of cleared biomass. Carbon losses are offset to some extent by the portion of harvested biomass that is converted to durable wood products (carbon storage in product use), and for that portion converted to renewable energy and displaces fossil energy use that otherwise would be used. Because conversion of forestland to developed land uses typically is permanent, replacement biomass does not grow back on the site to offset removals of live biomass (i.e., to the levels that existed during forest use).

- CH4: New research indicates that about four percent of the carbon storage benefits of live forests is offset by methane release (Nature 2006). Methane can be released from land filled biomass under anaerobic conditions.
- Black Carbon: Emissions of black carbon (soot) result from combustion of biomass from open burning during land clearing, but the heating effect is likely to be offset by the large amount of organic material that is also emitted during biomass combustion (Hansen 1992; CCS 2006).

Estimated GHG Savings and Costs Per MtCO$_2$e (for quantified actions):

- GHG potential in 2010, 2020: 0.31 MMtCO2e/yr reduced in 2010 and 2020.
- Net Cost per MtCO$_2$e: not quantified.

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Carbon stocks and above ground carbon densities are derived from the Forest Inventory Analysis (FIA) volumetric measurements conducted on a five-year cycle by the USDA Forest Service (Alerich 2004). Land cover change data is provided by FIA data and by the USDA Natural Resource Inventory (NRI), also gathered on a five-year cycle (insert NRI cite). Both data sets are based on a system of numerous state level plots that provide periodic measurements of land cover. Carbon densities for soil carbon are based on recent field estimates (Amichev 2004). Estimates of the portion of cleared biomass converted to commercial wood products and energy recapture, including logging and mill residue generation, are provided by field estimates (Birdsey 1996; Row 1996). Marginal displacement coefficients for avoided energy use are provided by the Energy Supply TWG and are derived from regional National Energy Modeling System (NEMS) data provided by the US Energy Information Administration (EIA) (insert cites).
- **Quantification Methods:** Spreadsheet analysis.
- **Key Assumptions:** Some rangeland carbon estimates are not currently included in forest carbon estimates due to data limitations; however, "Nonstocked" and "Pinyon Juniper" forest stands as defined by FIA include many lands classified as "Rangeland" by NRI. Forecasted carbon stock measurements from 2002 to 2020 are based on extrapolations of past trends from 1982-2002 and assume a static continuation of all land cover and land use dynamics during that period. Implementation mechanisms are assumed to be "growth neutral" to avoid offsetting development impacts, i.e. land protection does not result in land clearing in other areas (also referred to as "leakage"). Cost savings from

avoided land clearing costs may be contingent on regulatory acceptance of alternative land development approaches, such as conservation design or cluster development.

Key Uncertainties:

- Benefits: The rate at which live biomass stocks would have declined beyond business as usual due to forest health and forest fire risks may be significant. The rate of offsetting development effects from land protection may be sensitive to the design of policy implementation tools.
- Costs: Regulatory acceptance of alternative development approaches by local governing bodies may affect potential cost savings of avoided land clearing costs.

Ancillary Benefits and Costs, if applicable:

- Protection of working lands for sustainable wood products use, recreation, cultural and natural heritage.
- Environmental asset protection, including watersheds, wildlife and air quality.
- Reduced costs of infrastructure and services for dispersed or low density development.
- Reduced transportation emissions from increased location efficiency.
- Certain biomass combustion technologies may result in significant air pollution.

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

F-2 Reforestation/Restoration of Forestland

Policy Description: Expand forest cover (and associated carbon stocks) by regenerating or establishing forests in areas with little or no forest cover at present.

Policy Design:

- **Goal levels:** From the TWG, we need to determine the number of acres of previously forested lands to be restored to their native forested state. 430,000 acres of forestland regenerated/established at stocking rates of 47 tons of above ground biomass per acre.
- **Timing:** 430,000 acres of forestland regenerated/established from 2008-2020,

including approximately 70,000 acres regenerated/established by 2010 and 360,000 acres between 2010 and 2020. Average of 33,000 acres/yr.

- **Parties:**
- **Other:**

Implementation method(s): (provide category from standard CCS list, with details as needed)

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO2: Carbon savings occur when forest carbon stocks (trees, shrubs, and soil organic carbon) are established and sustained above and beyond existing levels.
- CH4: New research (Nature 2006) indicates that about four percent of the carbon storage benefits of live forests are offset by methane release.

Estimated GHG Savings and Costs Per MTCO$_2$e (for quantified actions):

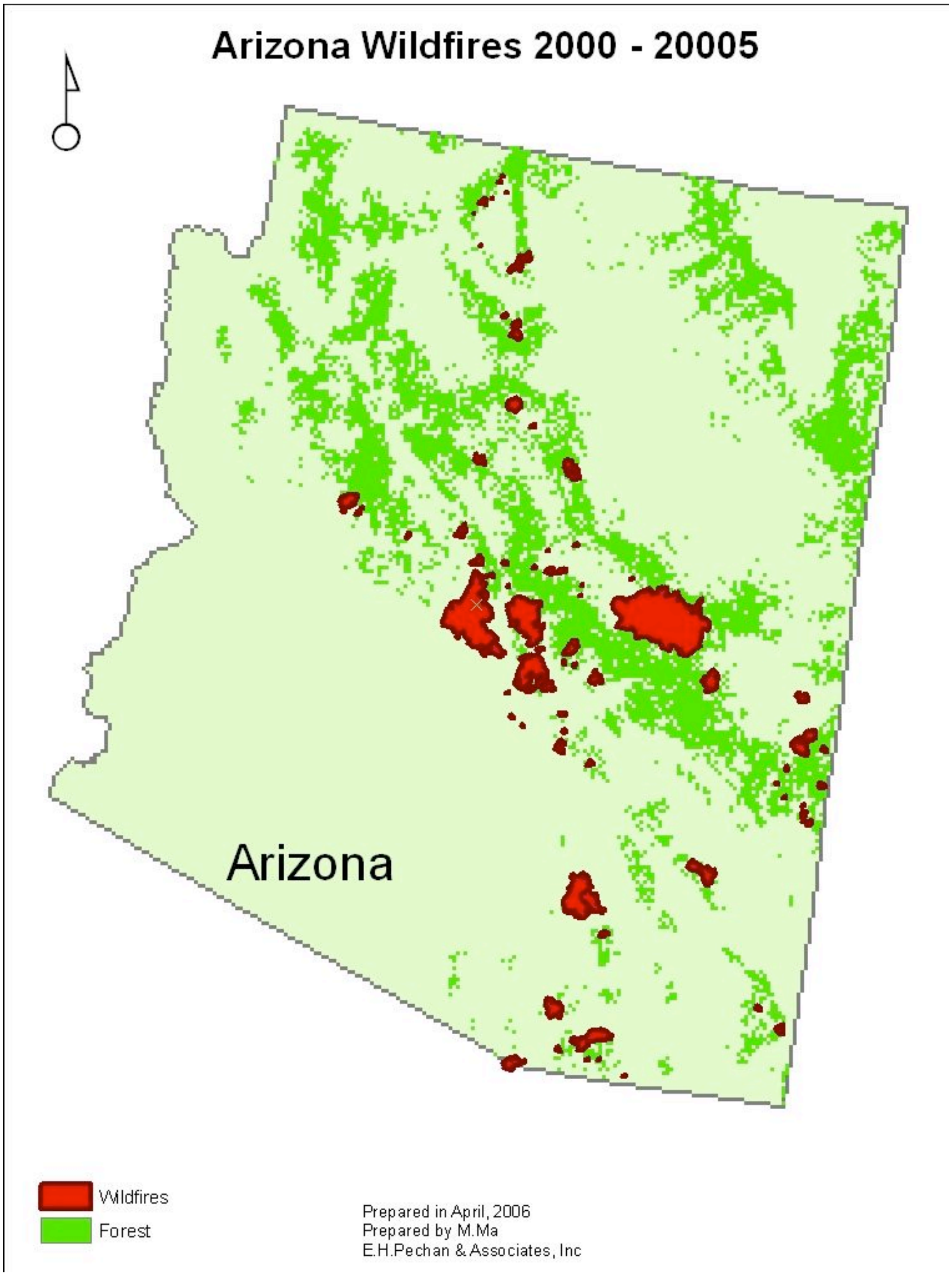
- GHG reduction potential in 2010, 2020: 0.03 MMtCO2e/yr in 2010 (2020 – see worksheet)
- Net Cost per MtCO$_2$e: To be determined. Information needed on forest restoration costs for the southwestern U.S.

Data Sources, Methods and Assumptions (for quantified actions):

- Data Sources: Acres burned in AZ between from 2000 – 2005 were obtained from USFS[1]. The total acres burned were used as the basis for the acreage to be reforested. A map of these areas is provided below. Carbon stocks and above ground carbon densities are derived from the Forest Inventory Analysis (FIA) volumetric measurements conducted on a five-year cycle by the USDA Forest Service (Alerich 2004).
- Quantification Methods: Reforestation of 5% of the burned areas was assumed for the 2008 – 2010 period. Another 25% of the burned areas was assumed to be reforested within the 2010 – 2020 time-frame. The amount of carbon to be sequestered on these lands was determined using the average above-ground carbon stocking for AZ forestlands based on the AZ Inventory & Forecast. The length of time for each restored stand to reach maturity was assumed to be 50 years. It was further assumed that without restoration, it would take 100 years for each stand to reach maturity.
- Key Assumptions: Rates of forest regeneration (i.e. 2% annual biomass

[1] Fire Perimeter data from D. Ryerson USFS, http://www.fs.fed.us/r3/gis/datasets.shtml; http://www.fs.fed.us/r3/gis/az_data.shtml.

replacement in restored areas; 1% annual replacement without restoration) need to be reviewed by the TWG.



Key Uncertainties:

- Benefits: The rate at which live biomass is regenerated on restored lands versus lands that do not receive any restoration treatment.
- Costs: The TWG is still looking for information on the costs associated with restoration of southwestern U.S. forests.

Ancillary Benefits and Costs, if applicable:

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

F-3a Forest Ecosystem Management – Residential Lands

Policy Description: Manage sustainable thinning or biomass reduction from residential forestlands (intended to address fire and forest health issues) so that harvested biomass is directed to wood products and renewable energy instead of open burning or decay.

Policy Design:

- **Goal levels:** Wildfire and other threats to forest health and sustainability, and community safety have led to a number of initiatives within the state of Arizona to reduce biomass in residential forests and woodlands. Most of these efforts include some emphasis on utilizing the extracted woody biomass for wood products and/or energy production, rather than eliminating these materials through open burning, or storage or decay off site. Although this is an existing or potential objective for many restoration and biomass treatments on these lands, a greater emphasis and focus on wood products and/or energy production, through appropriate mechanisms, incentives, etc., is recommended. In particular, a reasonable goal of utilizing 50% or more of biomass extracted from residential lands for wood products and/or energy production is recommended to be achieved by 2010 and continuing through 2020. We also recommend that current and planned fuels treatments in Arizona be accelerated, so that all high priority areas (e.g., in wild land urban interface) are treated by 2015. We further recommend that forest management practices and policies aimed at GHG reduction and carbon sequestration be reviewed by and coordinated with the Governor's Forest Health Oversight Council and Forest Health Advisory Council. It is quite likely that some policies already recommended by these councils, or may be recommended by the councils, are complementary and supportive of GHG reduction and carbon sequestration goals, while also promoting forest and ecosystem health and public safety. One of the key initiatives of the Forest Health Councils is a plan called "Sustainable Forests, Economies and Communities: A Statewide Strategy for Arizona Forests." This plan calls for spatial database development and hazard assessment, and prioritized treatments, among other things.

- **Timing:** see text above.
- **Parties:**
- **Other:**

Implementation method(s): (provide category from standard CCS list, with details as needed)

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO2: Carbon savings occur when live and dead carbon stocks (trees, shrubs) that otherwise would decay or burn in the forest, or be left for decay and or open burning following harvest, are harvested and converted to: 1) durable wood products that store carbon; 2) to low embedded energy wood building materials that substitute for high embedded energy conventional building materials (steel and concrete); or 3) to renewable energy that displaces fossil energy use. Sustainable management ensures that replacement biomass grows back to the maximum extent on thinned sites to offset removals of live biomass.
- CH4: New research (Nature 2006) indicates that about four percent of the carbon storage benefits of live forests is offset by methane release. Methane can be released from land filled biomass under anaerobic conditions.
- Black Carbon: Emissions of black carbon (soot) result from combustion of biomass from open burning of land clearing, but the heating effect may be offset by the large emissions of organic material associated with biomass combustion (CCS, 2006).

Estimated GHG Savings and Costs Per MtCO_2e (for quantified actions):

- GHG potential in 2010, 2020: Approximately 0.53 MMtCO2e/yr in both 2010 and 2020. Assumes that all biomass from mechanical treatments is diverted to energy use (displacing natural gas) and that 50% of all biomass treated by fire is diverted to energy use.
- Net Cost per tCO_2e: -$76 (based solely on displacement of natural gas; does not account for capital and annual costs associated with new biomass fired equipment.)

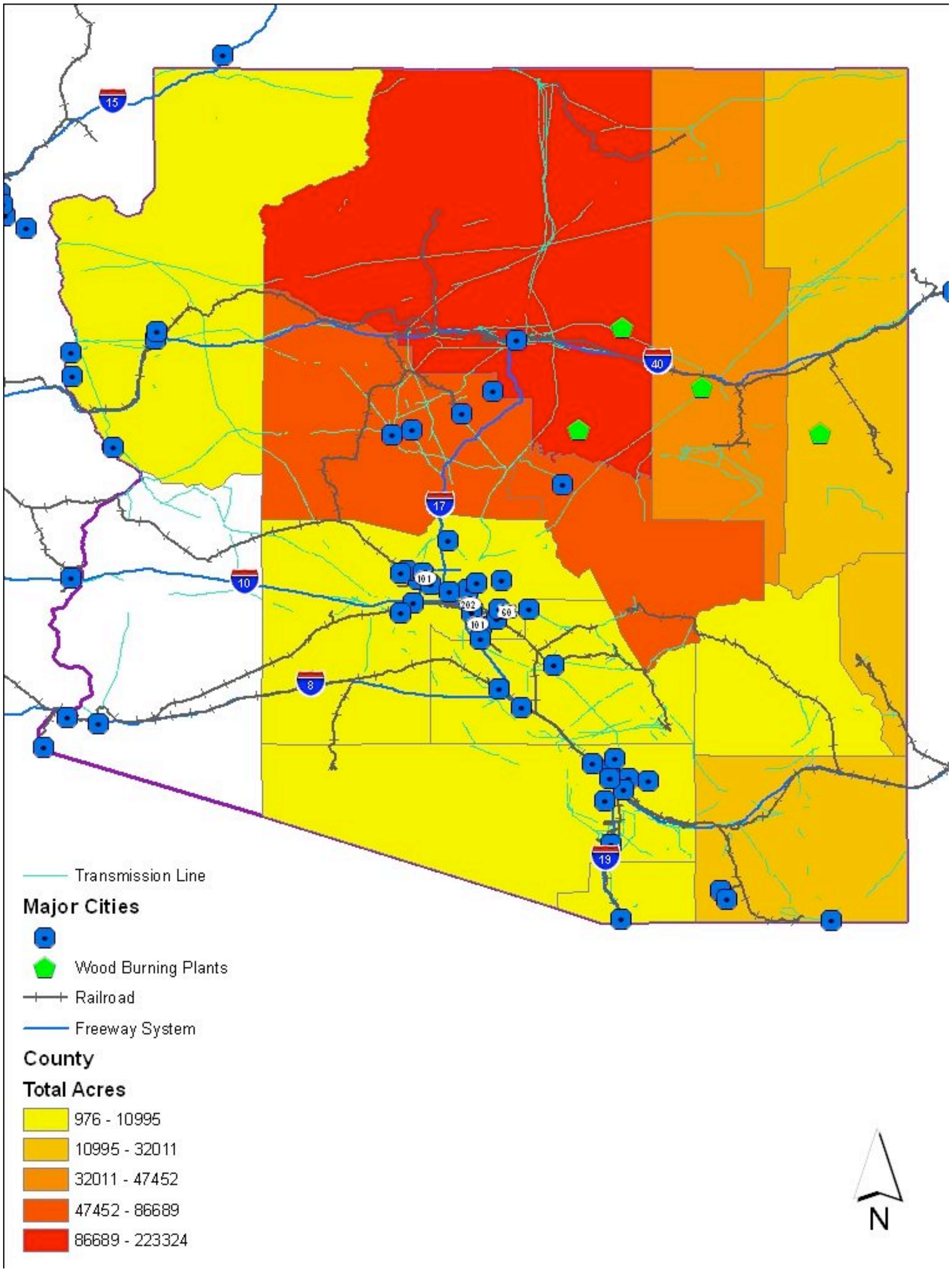
Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** CCS obtained data on both mechanical and fire treatments conducted in AZ from 2001 – 2006.[2] These data contained information on treatments that had occurred on both wildland-urban interface (WUI) lands and non-WUI lands. The WUI lands are those considered to be residential areas applicable to this option. The average acres treated during these years was used as the starting point for analysis. A map is provided below, which has county-level information (highest level of geographic resolution that the USFS would provide) on the total number of areas treated from 2001-2006, population centers, interstates, rail, transmission lines, and the small number of biomass plants currently operating in AZ. The average carbon stocking on AZ forestlands was taken from the USFS data that underlie the AZ Inventory & Forecast (i.e. USFS FIA). Estimates of the fraction of biomass to be removed in WUI and non-WUI areas was taken from an assessment by a researcher at Colorado State University.[3] A reduction in basal area of 42% associated with an "Intermediate Restoration Level" was selected for WUI lands. The reduction in basal area was assumed to be representative of a reduction in biomass density.

- **Quantification Methods:** The amount of biomass removed was then calculated by multiplying the annual acres treated by the above ground carbon density and the treatment fraction (0.42). CCS assumed that all of the biomass from mechanically-treated areas would be diverted to energy use (space heat), while biomass from 50% of the fire treated acreage would be diverted. The heat content associated with the diverted biomass was then used to estimate the equivalent amount of natural gas offset (with no adjustment for potential differences in energy efficiency). Emissions from this offset natural gas were quantified as the benefit of this option. No effort was made to quantify the embedded energy (and CO2e) associated with biomass diversion (neither were the life-cycle emissions associated with natural gas production and delivery investigated).

- **Key Assumptions:** Historical treatment areas are representative of future treatment programs. The average AZ forest carbon density is representative of areas requiring treatment (areas requiring treatment could be stocked at levels higher than the state average). Restoration levels selected for analysis are representative of those to be achieved in future practice.

[2] J. Roland, USFS, email communication with S. Roe, CCS, 4/26/06. Data from the National Fire Plan Operations and Reporting System (NFPORS) database.
[3] Brett Dickson, CO State Univ.; data provided to George Koch of the AZ AF TWG on 4/05/06, (DiameterClassTable_forGWK_040506.xls); "Intermediate Restoration" level of treatment; reduction in basal area assumed to be representative in reduction in above-ground biomass.



Key Uncertainties:

- Benefits: These initial estimates only account for utilization of the biomass as an energy source. Some fraction of this biomass could also find its way into merchantable timber. The benefits of this route of sequestration were not quantified. The market demand for new supplies of wood products and renewable energy is dynamic and not likely to fully absorb all new supply sources without offsetting decreases in other sources, unless there is support from policies that expand the market and, potentially, establish preferential treatment of these products in comparison to conventional supplies. The rate of biomass replacement growth in thinned stands is likely to be less than full due to ecological barriers and forest health issues, but the exact rates of replacement are estimated based on expert field judgment.

- Costs: As noted above, costs are based solely on displacement of natural gas. Capital and annual costs associated with new biomass fired equipment (e.g. municipal boilers or residential pellet stoves) are not captured in this assessment. Future cost reductions for wood product development and biomass energy recapture technologies are likely to fall with market expansion and "learning by doing" but are difficult to estimate at this time.

Ancillary Benefits and Costs, if applicable:

- Protection of residential and or municipal lands from fire risk.
- Expansion of markets for industrial producers of sustainable wood products and renewable energy use. Creation of Arizona jobs in the associated forestry management industries.
- Environmental asset protection, including watersheds, wildlife and air quality.

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

F-3b Forest Ecosystem Management – Other Lands

Policy Description: Increase sustainable thinning of biomass from forests and direct the harvested wood and wood waste to wood products and renewable energy.

Policy Design:

- **Goal levels:**

Scenario 1:

Wildfire and other threats to forest health and sustainability have led to a number of initiatives within the state of Arizona to reduce biomass in forests and woodlands. Many of these efforts include some emphasis on utilizing the extracted woody biomass for wood products and/or energy production, rather than eliminating these materials through open burning, or storage or decay off site. Although this is an existing objective or potential objective for many restoration and biomass treatments on these lands, a greater emphasis and focus on wood products and/or energy production, through appropriate mechanisms, incentives, etc., is recommended. In particular, a reasonable goal of utilizing 50% or more of biomass extracted for wood products and/or energy production is recommended. We also recommend that current and planned fuels treatments in Arizona be accelerated, so that all high priority areas (e.g., in valuable watersheds and habitats) are treated by 2015 and continuing through 2020.

We further recommend that forest management practices and policies aimed at GHG reduction and carbon sequestration be reviewed by and coordinated with the Governor's Forest Health Oversight Council and Forest Health Advisory Council. It is quite likely that some policies already recommended by these councils, or may be recommended by the councils, are complementary and supportive of GHG reduction and carbon sequestration goals, while also promoting forest and ecosystem health and public safety. One of the key initiatives of the Forest Health Councils is a plan called "Sustainable Forests, Economies and Communities: A Statewide Strategy for Arizona Forests". This plan calls for spatial database development and hazard assessment, and prioritized treatments, among other things. This strategic plan is still in draft form (as of 02/21/06), and it would be useful to coordinate objectives and strategies of various forest and woodland policy options from the CCAG with this plan.

Scenario 2:

Accelerated restoration levels are anticipated as economic utilization activity increases demand for small diameter timber and woody biomass and decreases amounts paid for restoration/fuel reduction treatments through "service contracts" and actually results in land managers being paid for material removed through "timber sales" - as one measure, under current conditions approximately 52,800 acres of US Forest Service land was projected to be treated by forest thinning in 2005, with 195,700 CCF of timber 5" dbh or greater removed and 229,200 tons of residue generated;

Timing of implementation: an average of 53,700 acres of US Forest Service land on 6 national forests are proposed to be treated per year by thinning from 2005 thru 2015, with an annual average of 192,500 CCF of timber over 5" dbh removed and 248,800 tons of residue generated, under current conditions. The acreage used to estimate benefits were taken from historical USFS treatment data (see data sources for F-3a above). For non-WUI areas, the acreage used was slightly lower than the initial policy design noted above. Annual acres treated from 2008 through 2020 are approximately 45,000;

Other: Current emphasis is on the wildland/urban interface zones throughout the state where communities and infrastructure are threatened by destructive wildfire, most have developed "Community Wildfire Protection Plans"; AZ Forest Health Oversight/Advisory Councils are developing a proposal – "Sustainable Forests, Economies and Communities: A Statewide Strategy for Arizona Forests" that will prioritize treatments statewide; focus mostly on ponderosa pine forests, but pinyon-juniper woodland treatments also needed.

- **Timing of implementation:** See discussion above.
- **Parties:** US Forest Service; AZ State Land Dept.; DOI; Tribal lands; fire department & fire district fuel management crews; private landowners; local community based groups – AZ Sustainable Forest Partnership, Greater Flagstaff Forests Partnership, Prescott Area Wildland/Urban Interface Commission, etc.

Implementation method(s): To be determined.

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO2: Carbon savings occur when live and dead carbon stocks (trees, shrubs) that otherwise would decay or burn in the forest are harvested and converted to: 1) durable wood products that store carbon; 2) to low embedded energy wood building materials that substitute for high embedded energy conventional building materials (steel and concrete); or 3) to renewable energy that displaces fossil energy use. Sustainable management ensures that replacement biomass grows back to the maximum extent on thinned sites to offset removals of live biomass.
- CH4: New research (Nature 2006) indicates that about four percent of the carbon storage benefits of live forests is offset by methane release. Methane can be released from land filled biomass under anaerobic conditions.
- Black Carbon: Emissions of black carbon (soot) result from combustion of woody biomass from open burning of land clearing, but the heating effect is likely to be offset by the cooling from the large amount of organic material emitted from biomass combustion (CCS, 2006).

Estimated GHG Savings and Costs Per $MtCO_2e$ (for quantified actions):

- GHG potential in 2010, 2020: 0.24 MMtCO2e/yr in both years (assumed constant treatment acreage)
- Net Cost per tCO_2e in 2010, 2020: -$76 (prior to discounting)

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** See discussion under F-3a above for a description of the data sources used. For non-WUI areas, the treatment level was assumed to be the

"Fuels Reduction" level of restoration from the same source cited under F-3a. This led to a 21% reduction in biomass (and carbon) density on the treated acres.

- **Quantification Methods:** See the discussion under F-3a. The same approach was applied for non-WUI lands using a different level of treatment (21% reduction) as mentioned above.
- **Key Assumptions:** Forecasted carbon stock measurements from 2002 to 2020 are based on extrapolations of past trends from 1982-2002 and assume a static continuation of all land cover and land use dynamics during that period. New supplies of biomass are assumed to enter the market without resulting in offsetting reduction of other supply sources; new supplies are assumed to expand the market.

Key Uncertainties:

- Benefits: The market demand for new supplies of wood products and renewable energy is dynamic and not likely to fully absorb all new supply sources without offsetting decreases in other sources, unless there is support from policies that expand the market and, potentially, establish preferential treatment of these products in comparison to conventional supplies. The rate of biomass replacement growth in thinned stands is likely to be less than full due to ecological barriers and forest health issues, but the exact rates of replacement are estimated based on expert field judgment.
- Costs: Future production cost reductions for wood product development and biomass energy recapture technologies are likely to fall with market market expansion and "learning by doing" but are difficult to estimate at this time.

Ancillary Benefits and Costs, if applicable:

- Protection of working lands and associated industries for sustainable wood products use, recreation, cultural and natural heritage.
- Expansion of markets for industrial producers of sustainable wood products and renewable energy use. Creation of Arizona jobs in the associated forestry management industries.
- Environmental asset protection, including watersheds, wildlife and air quality.

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

F-4 Improved Commercialization of Biomass Combustion, Gasification and Combined Cycle

Policy Description: Accelerate the rate of technology development and market deployment of biomass combustion, gasification and combined cycle (BGCC) technologies.

Policy Design:

- **Goal levels:** 10 megawatts of biomass energy between 2006 and 2010, and an additional 25 megawatts between 2010 and 2020 (or equivalent amount of new biomass thermal energy).
- **Timing:** see above.
- **Parties:** Western Energy Resources (Eager); Renergy Systems (Snowflake); Northern Arizona University (Flagstaff); Camp Navajo/Volunteer Mountain Industrial Park (Bellemont); Forest Energy (Snowflake & Bellemont); Arizona Public Service, APS Energy Services; Salt River Project; Tucson Electric Power; Rural Electric Cooperatives
- **Other:** technology improvements required to reduce emissions & improve efficiency of direct combustion; development of full scale commercial gasification systems needed; improved efficiencies for alcohol production from cellulose needed; appropriate technologies to efficiently remove and transport biomass from forests need to be in place

Implementation method(s): Funding mechanisms and or incentives [USDA/DOE Biomass Initiative RFP; private investment; surcharges on Renewable Energy Standard & Tariff (RES, formerly EPS)], Voluntary and or negotiated agreements [power purchase agreement; stewardship contracts to assure supply of biomass], Codes and standards [Environmental Portfolio Standard revisions, proposed as RES], Market based mechanisms [green tags & RES credits], Pilots and demos [gasification systems; 3 MW ChipTek Unit of APS; Western Energy Resources; Renergy], Research and development [NAU systems]

Related Policies/Programs in place: USDA/DOE Biomass Initiative; RES proposals approved.

Types(s) of GHG Benefit(s):

- CO_2: Carbon savings occur when biomass energy combustion processes are converted from conventional technology to new technologies with greater thermal efficiency and reduced emissions with lower pollution outputs. New conversion technologies also may expand the use of available biomass supplies that substitute biomass energy for conventional fossil fuels. Increased efficiency & reduced emissions from burning/gasifying biomass in plants rather than "slash burning" in the forest as currently done. There will be significant reductions in CO2 released from wildfire combustion of forest biomass when thinning treatments restore forest health and reduce the occurrence, areal extent and intensity of wildfires; needs to be offset with contributions from increased prescribed burning necessary to maintain forest health.

- CH4: New research (Nature 2006) indicates that about four percent of the carbon storage benefits of live forests is offset by methane release. Methane can be released from land filled biomass under anaerobic conditions.
- Black Carbon: Emissions of black carbon (soot) result from combustion of woody biomass from open burning of land clearing, but the heating effect is likely to be offset by the cooling effects of the large amount of organic material emitted during biomass combustion (CCS, 2006).

Estimated GHG Savings and Costs Per $MMTCO_2e$ (for quantified actions):

- GHG potential in 2010, 2020: Not quantified (forest biomass energy currently quantified under Options F-3a and F-3b.
- Net Cost per $MMTCO_2e$ in 2010, 2020

Data Sources, Methods and Assumptions (for quantified actions):

- Data Sources: Steve Gatewood, AF TWG, provided the following –
  - The existing 3MW Eager WER/APS plant consumes 110 tons/day of 40% moisture biomass, with approx. 46 tpy PM10, 52 tpy PM, 95 tpy CO, 4 tpy SOX, 35 tpy NOX & 6 tpy VOC; cost unknown
  - The ChipTek 3MW plant (not online yet – may go to NAU) consumes ~100 tons/day of 20% moisture chips, with approximately 45 tpy PM10, 52 tpy PM, 94 tpy CO, 4 tpy SOX & 35 tpy NOX; cost is about $7.8
  - The proposed/permitted 24MW Renergy Snowflake plant would consume 480 tons/day of 50% moisture biomass, with approx. 23 tpy PM10, 252 tpy CO, 156 tpy SOX, 205 tpy NOX & 22 tpy VOC; cost is unknown
  - A 10MW plant proposed for Snowflake that might be replaced by the above 24 MW would use 295 tons/day of 38% moisture biomass, with 44 tpy PM10, 58 tpy CO, 11 tpy SOX, 57 tpy NOX & 8 tpy VOC; cost unknown
  - A 10MW gasification system proposed for NAU would use 248 tons/day of 40% moisture biomass, with unknown emissions; cost would be ~ $15M
- Quantification Methods:
- Key Assumptions:

Key Uncertainties:

- Benefits: The market demand for new supplies of renewable energy is dynamic and not likely to fully absorb all new supply sources without offsetting decreases in other sources, unless there is support from policies that expand the market and, potentially, establish preferential treatment of these products in comparison to conventional supplies.
- Costs: Future production cost reductions for biomass energy recapture technologies is likely to fall with market expansion and "learning by doing" but are difficult to estimate at this time.

Ancillary Benefits and Costs, if applicable:

- Criteria air pollution levels are lower with advanced technology. Gasification reduces emissions below direst combustion. Alcohol production even further.
- Expanded biomass energy use also expands rural biomass industries.
- Eliminates open burning of slash – reduced smoke impacts and emissions and scarification of soils with resulting exotic species invasions.
- Significant reductions in emissions & pollutants through controlled combustion or gasification compared to open burning of slash or large wildfire releases.
- Criteria air pollution levels are lower with advanced technology than conventional biomass technology. Emission levels might not be as low as some conventional fossil fuel technologies (e.g., natural gas combustion technologies)
- Expanded biomass energy use also expands rural biomass industries.

Feasibility Issues, if applicable:

Status of Group Approval: Pending

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-1a Manure Management - Manure Digesters

Policy Description: Reduce CH4 emissions from livestock manure through the use of manure digesters installed at dairies. Energy from the manure digesters is used to create heat or power, which offsets fossil fuel-based energy production and associated CO2 and black carbon emissions.

Policy Design:

- **Goal levels:** Manage dairy manure using anaerobic digesters and energy capture technology (e.g. electricity generators) covering 15% of the state-wide dairy population by 2010. Increase this level to 50% of the dairy population by 2020.

Because use of manure digesters at beef feedlots are not as far along in development as dairy applications, implement at least three demonstration projects at large beef feedlots (>5,000 head) by 2010. This represents about 5% of the current feedlot population. Expand the use of digesters at beef feedlots to 50% of the feedlot population by 2020. For at least one of these demonstration projects, investigate the use of combined manure digester and ethanol production plants. In these projects, the spent grain from the ethanol process is used as feed for the cattle. Heat and electricity produced from the manure digester is used in the ethanol plant to reduce fossil-based energy use.

- **Timing:**
- **Parties:**
- **Other:**

Implementation method(s): To be determined.

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO2: Use of methane captured in manure digesters to generate electricity displaces fossil fuel use and associated CO2.
- CH4: Manure digesters collect and combust the CH4 produced from anaerobic decomposition during manure storage.
- N2O emissions from manure management are not likely to be affected by this policy option. N2O emissions from fossil fuel-based electricity will be offset.
- Black Carbon: Use of methane captured in manure digesters to generate electricity displaces fossil fuel use and associated BC emissions.

Estimated GHG Savings and Costs Per MtCO$_2$e (for quantified actions):

- GHG potential in 2010, 2020: 2010 Dairies = 0.12 MMtCO2e; 2020 Dairies = 0.37 MMtCO2e; Feedlots 2010 = 0.0004 MMtCO2e; 2020 Feedlots = 0.007 MMtCO2e.
- Net Cost per MtCO$_2$e in 2010, 2020: 2010 Dairies = $12/MtCO2e; 2020 Dairies = $11.60/MtCO2e; 2010 Feedlots = $1,060/MtCO2e; 2020 Feedlots = $600/MtCO2e.

Based on the high costs and moderate GHG reductions for feedlots, only the benefits and costs for dairies are included in the policy summary at the beginning of this document.

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources: See CCS Spreadsheet.**
- **Quantification Methods: See CCS Spreadsheet.**
- **Key Assumptions: See CCS Spreadsheet.**

Key Uncertainties:

Ancillary Benefits and Costs, if applicable:

- Reduction of ammonia, VOC emissions, and odor.
- Reduction of fossil fuel-based energy consumption.
- Could enhance the value of manure through higher demand for manure overall and potentially higher quality of digested manure.

Feasibility Issues, if applicable:

- In the U.S. about 7% of greenhouse gas emissions are from agriculture, with the major source of agricultural emissions being nitrous oxide from agricultural soils. About 25% of agricultural emissions come from waste management activities and about 25% from enteric fermentation. We have a lot of interest in developing domestic energy sources, especially in rural areas where electricity is more difficult and expensive to obtain. We would like to focus on making some of these technologies more affordable (e.g., high initial cost of anaerobic digesters compared to other management methods).
- Need to identify methods for integrating this form of distributed power into the power grid in AZ.

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-1b Manure Management – Land Application

Policy Description: Reduce N20 emissions from daily spread and other land application of dairy and feedlot cattle manure through the use of better application methods, such as direct injection of liquid waste. These application methods are designed to reduce contact of manure nitrogen with air (lowering the rate of denitrification) and the amount of manure nitrogen loss via leaching and runoff.

Policy Design:

- **Goal levels:** Program goal of changing manure land application methods for X% of beef and dairy cattle.

- **Timing:** Fraction of dairy and feedlot cattle affected by these new application methods by 2010, 2020 and 2050.
- **Parties:**
- **Other:**

Implementation method(s): To be determined.

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- N2O: Reduces N20 emissions by minimizing manure nitrogen contact with air; or nitrogen losses via leaching or runoff which result in subsequent N20 emissions.

Estimated GHG Savings and Costs Per MMTCO$_2$e (for quantified actions):

- GHG potential in 2010, 2020
- Net Cost per MMTCO$_2$e in 2010, 2020

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources: Straw Proposal and Quantification in Progress.**
- **Quantification Methods:**
- **Key Assumptions:**

Key Uncertainties:

Ancillary Benefits and Costs, if applicable:

- Reduction of ammonia, VOC emissions, and odor.
- Increased in nitrogen utilization by crops and pastures.
- Decreased leaching and runoff of nitrogen to ground and surface water.

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-2 Biomass Feedstocks for Electricity or Steam Production

Policy Description: Displace fossil fuel usage through the use of agricultural waste (e.g., orchard trimmings, other crop residue) as a feedstock for electricity or steam production.

Policy Design:

- **Goal levels:** Program goal of using 50% of available agricultural biomass for residential heating by 2020.
- **Timing:** 20% of available biomass used by 2010, 50% by 2020.
- **Parties:**
- **Other:**

Implementation method(s): (provide category from standard CCS list, with details as needed)

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO2: Savings occur as a result of displacing fossil fuel use in the production of electricity or steam.
- CH4: Not applicable (savings only occur if it can be demonstrated that biomass combustion produces less methane than fossil-based combustion)
- N2O: Not applicable (savings only occur if it can be demonstrated that biomass combustion produces less methane than fossil-based combustion)
- HFC's, SFC's: Not applicable
- Black Carbon: Likely to be a reduction in BC emissions to the extent that coal-based combustion is offset.

Estimated GHG Savings and Costs Per MtCO_2e (for quantified actions):

- GHG potential in 2010, 2020: 0.04 MMtCO2e in 2010, 0.10 MMtCO2e in 2020
- Net Cost per MtCO_2e in 2010, 2020: -$93/MtCO2e

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Harvested acres for corn grain, sorghum, barley, oats, winter wheat, and durum wheat, and orchards were obtained from USDA NASS[4]. Per acre crop residue yields for grain crops were taken from a joint study by the USDA and US DOE[5]. An estimate of biomass yields from orchard trimmings

[4] AZ State Agriculture Overview – 2005, http://www.nass.usda.gov/Statistics_by_State/Ag_Overview/AgOverview_AZ.pdf

[5] Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply, 2004, http://www.ethanolrfa.org/objects/documents/92/billion_ton_vision.pdf

was taken from a report from the National Renewable Energy Laboratory[6]. Estimates of the energy content in kWh/ton for switchgrass pellets (used to estimate crop residue) were obtained from Resource Efficient Agricultural Production Canada[7]. The energy content for wood pellets was taken from a wood pellet brochure[8]. The delivered costs for biomass pellets were obtained from Resource Efficient Agricultural Production Canada[9]. A comparison of the biomass resources available using the above data to the Western Governors' Association's Clean and Diversified Energy Advisory Committee's (CDEAC) report on regional biomass resources. However, the lack of AZ-specific information on non-manure biomass did not allow for a direct comparison.

- **Quantification Methods:** Acreage data and the tons of crop residue (or orchard trimmings) per acre were used to estimate the total amount of available biomass from existing crops. Estimates of the energy content for switchgrass pellets (19.3 MMBtu/ton) and wood pellets (16.4 MMBtu/ton) were used to estimate the total energy that could be generated using biomass pellets. The amount of CO2 generated from the combustion of an equivalent amount of natural gas was estimated using the residential natural gas emission factor from EPA's State Greenhouse Gas Inventory Tool (SGIT) (31.9 lbC/MMBtu). No adjustments were made for the potential differences in efficiencies between the natural gas fired and biomass fired equipment.
- **Key Assumptions:** Crop acreage for grains was assumed to remain constant for 2005-2020 and orchard acreage was assumed to remain constant for 2002-2020. The energy content and pelletizing costs for AZ crop residue were assumed to be the same as for an analysis of pelletized switchgrass conducted in Canada.

Key Uncertainties:

- **Benefits:** The values for crop residue yields are based on National values, and may differ for crops in Arizona. The energy content of Arizona crop residue may differ from that of switchgrass. Another uncertainty is the acreage of potential biomass crops in 2010 and 2020. The benefits are quantified as the amount of fossil fuel (natural gas) offset with biomass energy for space heating. Full life-cycle GHG benefits (i.e. embedded energy) for the production of pelletized biomass and natural gas were not incorporated into this analysis.
- **Costs:** The costs of production and transport of pellets made from crop residue and orchard trimmings may differ from that of switchgrass.

Ancillary Benefits and Costs, if applicable:

- Increased costs associated with collecting and transporting biomass.

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[6] Lessons Learned from Existing Biomass Plants, NREL, 2000, http://www.nrel.gov/docs/fy00osti/26946.pdf
[7] Grass Biofuel Pellets, http://www.reap-canada.com/bio_and_climate_3_2.htm
[8] http://www.energycentre.info/pdf/dokumentarkiv/brochure_about_wood_pellets.pdf
[9] Grass Biofuel Pellets, http://www.reap-canada.com/bio_and_climate_3_2.htm

- Increased emissions associated with collection and transport
- Decrease in emissions in some cases – e.g. situations where open burning of residue is replaced by controlled combustion.

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-3 Ethanol Production

Policy Description: Provide incentives for the production of ethanol from crops, agricultural waste, or other materials. Use of the ethanol will offset fossil fuel use (gasoline). Different incentive programs will be needed for crop (starch-based) ethanol production versus agricultural waste (cellulosic) ethanol production processes.

Policy Design:

- **Goal levels:** Three production goal options were assessed. The first involved production of enough ethanol to support the use of E10 (10% ethanol by volume in gasoline) year round in areas that currently use it during the winter season (Maricopa, northern Pinal, and Pima Counties). Year round use would more than double the current usage levels of ethanol in AZ. The second option involved producing enough ethanol to support alignment with the New Mexico CCAG goal of 20% ethanol usage by volume in gasoline by 2012. The third option was alignment with the NM CCAG goal of 40% ethanol by 2030.
- **Timing:** The timing for the first option is by 2010. This would require the production of 207 MMgal/yr. The second option is to be achieved by 2020, and it would require the production of 858 MMgal/yr at that time. The third option would require production of 3,450 MMgal/yr by 2050. Note: production from the new Pinal county facility is included in the forecasted goals.
- **Parties:**
- **Other:**

Implementation method(s): (provide category from standard CCS list, with details as needed)

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO_2: CO_2 emissions are reduced by offsetting the use of petroleum-derived gasoline and diesel. Energy requirements of producing ethanol need to be compared to the energy requirements of producing gasoline to completely assess the CO2 benefit.

- Black Carbon: Differences in BC emissions between gasoline and ethanol-blended gasoline are probably negligible.

Estimated GHG Savings and Costs Per MtCO$_2$e (for quantified actions):

Option 1:

- GHG reduction potential in 2010, 2020: 0.49 MMtCO2e; 0.64 MMtCO2e.
- Net Discounted Cost per MtCO$_2$e through 2020: $151

Option 2:

- GHG reduction potential in 2020, 2050: 4.03 MMtCO2e; 8.46 MMtCO2e
- Net Discounted Cost per MtCO2e through 2020: $149

Option 3:

- GHG reduction potential in 2050: 18.4 MMtCO2e

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** See CCS spreadsheet. Production volumes for each scenario in each year are based on forecasted gasoline consumption (from the AZ Inventory & Forecast), current and planned ethanol production in the state, and the volume of gasoline to be offset in each year. Costs for all ethanol production are based on estimates for cellulosic technology[10] and do not include the costs for the new Pinal Energy Plant.
- **Quantification Methods:** See CCS spreadsheet. Full lifecycle benefits for both starch-based and cellulosic ethanol production and gasoline production from Argonne National Lab's GREET Model were used to estimate CO2e reductions.
- **Key Assumptions: Production volumes are set at one of the selected scenarios. Current costs for cellulosic ethanol production are accurate and not expected to change considerably over the policy period (thru 2020).**

Key Uncertainties:

Ancillary Benefits and Costs, if applicable:

- Gasoline-ethanol blends may increase or decrease emissions of some criteria and

[10] Charles Bensinger, Sunbelt Biofuels, personal communication with S. Roe, CCS. Costs based on cellulosic plants in the 7 to 11 MMgal/yr production range. Plants use either manure or municipal solid waste as feedstock. Plants are profitable at ethanol prices of $1.90/gal (current price is $2.70/gal). Costs to produce cellulosic ethanol range from $1.28 - $1.40/gal.

toxic air pollutants.

- In-state job growth.

Feasibility Issues, if applicable:

Status of Group Approval: **(**Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-4 Change Livestock Feedstocks

Policy Description: Reduce methane emissions from beef and dairy cattle by changing (optimizing) livestock feedstocks.

Policy Design:

- **Goal levels:** Change feedstock for 50**%** of dairy and feedlot cattle to a feed regimen that lowers methane emissions.
- **Timing:** 20% of dairy and feedlot cattle on methane lowering diet by 2010, 50% by 2020.
- **Parties:**
- **Other:**

Implementation method(s): To be determined.

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CH4: Addition of edible oils to feedstocks can reduce CH4 emissions from enteric fermentation in cattle. Vegetable oils are more dense digestible energy sources that require less fermentation in the rumen for energy to be released.

Estimated GHG Savings and Costs Per $MtCO_2e$ (for quantified actions):

- GHG potential in 2010, 2020: 0.029 MMtCO2e in 2010, 0.073 MMtCO2e in 2020
- Net Cost per $MtCO_2e$ in 2010, 2020: $244/MtCO2e

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** The populations of dairy and feedlot cattle in Arizona in 2004 were obtained from the USDA[11]. Emission reductions from the addition of edible oil to cattle feedstocks and the amount of oil consumed per head were taken from a study on the effects of various feed additives on enteric fermentation methane emissions[12]. Costs for edible oils were obtained from the USDA[13].
- **Quantification Methods:** Cattle populations were assumed to remain constant from 2004 levels to 2020. Emission savings were estimated by applying the 21% emission reduction to the estimated methane emissions for 20% of the population in 2010 and 50% of the population in 2020. Costs were estimated by multiplying the cost of soybean oil ($0.23 per lb) by the amount consumed by each head of cattle (400 g/head/day or 0.88 lb/head/day).
- **Key Assumptions:** Cattle populations were assumed to remain constant from 2004 levels to 2020. Soybean oil was chosen to estimate costs, because it is less expensive than sunflower oil (the oil used in the emissions study). It was assumed that any edible oil would produce a similar reduction of methane emissions.

Key Uncertainties:

Ancillary Benefits and Costs, if applicable:

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-6 Rotational Grazing/Improve Grazing Crops and/or Management

Policy Description: Increase carbon sequestration in grazing lands through rotational grazing, improvement of grazing crops, and/or grazing management.

Policy Design:

- **Goal levels:** Program goal of bringing **X** acres of poorly managed grazing land under new management practices.
- **Timing:** Acres of grazing land brought under new management practices by

[11] Arizona Annual Livestock, May, 2004, USDA NASS, http://www.nass.usda.gov/az/lvstk/2004/040525al.pdf
[12] McGinn et al., 2004, "Methane emissions from beef cattle: Effects of monenesin, sunflower oil, enzymes, yeast, and fumaric acid." http://jas.fass.org/cgi/content/full/82/11/3346
[13] Oil Crops Outlook, Feb, 2006, USDA ERS, http://usda.mannlib.cornell.edu/reports/erssor/field/ocs-bb/2006/ocs06bf.pdf

2010, 2020 and 2050.

- **Parties:**
- **Other:**

Implementation method(s): To be determined.

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO2: Carbon savings (sinks) are a result of enhanced sequestration on grazing lands. Sequestration is enhanced by using grazing management techniques that elevate the health status of plants on grassland ecosystems.

Estimated GHG Savings and Costs Per $MMTCO_2e$ (for quantified actions):

- GHG potential in 2010, 2020: TBD
- Net Cost per $MMTCO_2e$ in 2010, 2020: TBD

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:**
- **Quantification Methods:**
- **Key Assumptions:**

Key Uncertainties:

Ancillary Benefits and Costs, if applicable:

- Higher quality grassland habitat for wildlife.

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-7 Convert Agricultural Lands to Grassland or Forests

Policy Description: Increase carbon sequestration in agricultural land by converting marginal land used for annual crops to permanent cover (grassland or forests).

Policy Design:

- **Goal levels:** Program goal of converting **X** acres of marginal agricultural land to grassland or forest. Information on the native land cover associated with these marginal lands (forest, grassland) or their location can also be factored in to the assessment of above and below ground carbon change.
- **Timing:** Acres of land converted to grassland or forest by 2010, 2020 and 2050.
- **Parties:**
- **Other:**

Implementation method(s): To be determined.

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO2: Loss of carbon to the atmosphere from tillage and fallow land is reduced by converting land to permanent cover. This increases soil carbon content. Above ground carbon stocks are increased by converting to cover with a greater ability to sequester carbon (i.e. higher biomass).

Estimated GHG Savings and Costs Per MMTCO$_2$e (for quantified actions):

- GHG potential in 2010, 2020: TBD
- Net Cost per MMTCO$_2$e in 2010, 2020: TBD

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:**
- **Quantification Methods:**
- **Key Assumptions:**

Key Uncertainties:

Ancillary Benefits and Costs, if applicable:

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-8 Reduce Permanent Conversion of Farm and Rangelands to Developed Uses

Policy Description: Reduce the rate at which existing crop and rangelands are converted to developed uses. The carbon sequestered in soils and above-ground biomass is higher in crop and rangelands than in developed land uses.

Policy Design:

- **Goal levels:** Program goal of reducing the rate of crop and rangeland loss to 50% of the loss rate from 1982-1997 by 2020.
- **Timing:** 20% reduction in loss rate by 2010, 50% by 2020.
- **Parties:**
- **Other:**

Implementation method(s): To be determined.

Related Policies/Programs in place: To be determined.

Types(s) of GHG Benefit(s):

- CO2: Conservation of agricultural lands retains the ability of the land to sequester carbon in soil and biomass.

Estimated GHG Savings and Costs Per MtCO$_2$e (for quantified actions):

- GHG potential in 2010, 2020: 0.19 MMtCO2e; 0.46 MMtCO2e.
- Net Cost per MtCO$_2$e in 2010, 2020: TBD

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** The number of acres that moved from cropland, pasture, and rangeland categories to developed uses between 1982 and 1997 was obtained from the USDA Natural Resource Inventory (NRI). Agricultural land soil carbon data was taken from a study in *Soil Science* that compiled data for cultivated and uncultivated land with various soil types[14]. Estimates of soil carbon on Arizona rangeland was obtained from the STATSGO/SSURGO SOC database.
- **Quantification Methods:** The number of acres of cropland, pasture, and rangeland converted to developed uses between 1982 and 1997 was divided by 15 years to give the average number of acres lost each year. The number of acres to be saved in 2010 and 2020 were estimated by multiplying the average rate for 1982-1997 by 20% and 50%, respectively. The amount of CO2 emissions savings were estimated by assuming that for each acre lost to development, 10,000 sq ft (0.23 acre) losses 100% of the soil carbon. The remainder of the acre losses 25% of soil carbon.
- **Key Assumptions: Aboveground carbon stocks for agricultural lands and**

[14] Mann, L.K. 1986. Changes in soil carbon storage after cultivation. Soil Science 142(5):279-288.

rangeland was assumed to be small compared to soil carbon. For each acre of land lost to development, 10,000 sq ft is assumed to loss 100% of the soil carbon. This area represents the area in buildings, streets, and other structures that cover the soil. A loss of 25% of the soil carbon is assumed for the remainder of the acre.

Key Uncertainties: The main areas of uncertainty are the existing soil carbon stocks and the change in soil carbon when land is developed.

Ancillary Benefits and Costs, if applicable:

- Transportation emissions may also be reduced by directing growth to more efficient locations.

Feasibility Issues, if applicable: To be determined.

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-9 Programs to Support Local Farming/Buy Local

Policy Description: This option seeks to promote consumption of locally-produced agricultural commodities, which would offset consumption of commodities transported from other states or countries. It includes the modification, enhancement and further development of local farm programs employed in Arizona to reduce transport-related GHG emissions.

Policy Design:

- **Goal levels:** The object of expanding local farm programs and coordinating existing community programs is to increase consumption of agricultural products from sources within Arizona. In addition to the benefits of reducing fuel usage, transportation costs and air pollutant emissions, consuming locally grown foods will directly support Arizona producers, consumers and retailers. This policy looks to increase consumption of Arizona grown commodities by 10%, thereby offsetting commodities transported from other states/countries by the same amount.
- **Timing:** While reducing greenhouse gases in Arizona and achieving a 10% increase in the consumption of local farm commodities, the expansion, coordination, development and implementation of local farm programs requires financial support and "cause marketing" that will connect consumers to the value of sustaining Arizona's agricultural industry. To achieve the goal of this policy, implementation milestones are estimated at 5% by 2010 and another 5% by 2020

(total of 10% offset in 2020).

- **Parties:** Agricultural producers, industry, communities, government and others in Arizona
- **Other:**

Implementation method(s): To be determined.

Related Policies/Programs in place: Community Supported Agriculture Farmers Markets, North American Farmer's Direct Marketing Association (NAFDMA), Farmers' Market Nutrition Program (FMNP), Arizona Grown Program, The 5-A-Day for Better Health Program, U-Pick Programs Greenhouse Production, Agritainment Business

Estimated GHG Savings and Costs Per $MtCO_2e$ (for quantified actions):

- GHG potential in 2010, 2020: 0.003 MMtCO2e, 0.01 MMtCO2e
- Net Cost per $MMTCO_2e$ in 2010, 2020: TBD

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Estimates of harvested acres, crop yields, and crop value and production estimates for beef and dairy products were taken from AZ Agricultural Statistics 2004. Estimates of state exports were obtained from the USDA Economic Research Service (ERS)[15]. U.S. per capita consumption rates were obtained from the ERS Food Consumption (Per Capita) Data System[16]. Arizona population data were obtained from the Arizona Department of Economic Security.
- **Quantification Methods:** The amount of each crop produced in Arizona was estimated using harvested acres and estimates of crop yields per acre. The amount of each crop consumed in Arizona was estimated using U.S. per capita consumption rates and the Arizona population. State export values were reported for commodity class. These values were allocated to each crop based on the crop value for each individual crop compared to the total value for all crops in the commodity class. Export values were then converted from dollars to weight using an estimated price calculated from the crop production value and amount produced for each crop. The amount consumed and exported for each crop was then subtracted from the amount produced to determine how much of the crop was imported. For each imported crop, a likely state of origin was chosen (CA for carrots, tomatoes, onions, grapes, eggs, and milk; OK for beef; Idaho for potatoes). The estimated amount of imports for each crop and the estimated mileage were then used to estimate ton-miles transported and CO_2 emissions. These calculations were repeated for 2010 and 2020 using population projections to estimate future consumption.
- **Key Assumptions:** Transportation emissions were estimated by assuming 23 tons of payload per truck, 6 truck miles per gallon of diesel fuel and 22.4 lb CO_2 per gallon of diesel fuel. To estimate miles traveled, food from CA was assumed to travel from Fresno to Phoenix (600 miles), food from OK was assumed to travel from Oklahoma City to Phoenix (1,000 miles), food from ID was assumed to travel from Boise to Phoenix (1,150 miles). The amount of food produced and exported is assumed to remain constant, while consumption is assumed to grow with population.

Key Uncertainties: One uncertainty is the amount of food products leaving the state. State export data from ERS includes only foreign exports. These estimates do not include state-to-state exports. Also, these estimates do not take into account that a large portion of some crops may be shipped out of state when they are in season, and imported into the state when they are not in season. The benefits were quantified at the state level. As such, they do not capture additional GHG benefits where local (e.g. community-level) production and consumption takes place (resulting in addition ton-

[15] State Export Data, http://www.ers.usda.gov/Data/StateExports/
[16] Food Availability: Spreadsheets, http://www.ers.usda.gov/Data/FoodConsumption/FoodAvailSpreadsheets.htm

mile reductions). The quantified benefits could also be conservatively low since the assumptions for out of state produce were based on the nearest likely producer state. Many commodities come from much further away (including foreign countries) and can travel by more energy intensive methods (e.g. air transport). Finally, the assumed transport routes are a single trip from city of origin to Phoenix. Many commodities will make several trips prior to reaching their final point of consumption (e.g. for packaging, storage, processing, etc.). The overall impact of all of the assumptions is that the benefits are underestimated by a large amount.

Ancillary Benefits and Costs, if applicable:

- Reduction in criteria and toxic air pollutants.
- Collaboration of local farm programs with other food programs provides nutritional education and increases the consumption of healthy foods for all Arizonans.
- Educate adults and children, about Arizona agriculture and agriculture's impact on their life. Support for local agricultural jobs.

Feasibility Issues, if applicable:

Status of Group Approval: Pending – Some group members felt that this option needed additional work in the development of implementation details and quantification of benefits and costs.

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):